the same time it is not improbable that the first outbursts may be dated back to the later Eocene, and the last to the period when the waters of the great Jordan-Valley Lake had receded from their original limits to those within which they are now restricted.

The physical details form but a small part of the volume, which contains a large number of carefully drawn figures of works of art and architecture, accompanied by descriptive text, showing that the region, now the abode of Fellahin—or of migratory Arabs—was one of importance during long centuries of successive dynasties and races. The book cannot fail to be of value to students of Biblical and ancient history, and we are promised by Herr Schumacher descriptive drawings and maps of another section of the Hauran country.

## HARBOURS

*The Design and Construction of Harbours. A Treatise on Maritime Engineering.* By Thomas Stevenson, P.R.S.E., &c. Third Edition. Pp. xiv. + 355. Twenty-four Plates. (Edinburgh: A. and C. Black, 1886.)

THIS work is a reprint, with large and valuable additions, of the article "Harbours" in the Encyclopædia Britannica." Its importance may be gauged from its acceptance in successive editions of that "Encyclopædia, and from its having passed into three editions in the separate and enlarged form.

An important feature is the attempt to lay down general principles, and to discuss and reduce as far as possible to calculation the effect of the great forces of wind and water, and to regulate both the general design and the details of constructions thereon. To the earlier engineers this was mere guesswork, *e.g.* Smeaton is said (p. 41) to have described these forces as "subject to no calculation." Many striking instances of the maximum effect of wind and waves are given, *e.g.* at the top of Whalsey Skerries (Zetland), at a height of 74 feet above high water, large blocks up to $13\frac{1}{2}$ tons were found to have been lifted and transported by the waves (p. 45). Again, two blocks of 1350 tons and 2600 tons were shifted bodily at the Wick breakwater in two storms in 1872 and 1877. At Dunbar, pressures of $3\frac{1}{2}$ tons per square foot for the direct wave-action (p. 56), and of 1 ton per square foot for the back-wash (p. 131), were recorded upon a dynamometer of the author's invention; and, by use of two instruments at different levels, it was found that the pressure at the upper level may (exceptionally?) be twice that at the lower level (p. 56). It is much to be wished that extensive and systematic observations of this kind were made, as instances are quoted wherein only 80, 144, and 70 lbs. per square foot had been assumed in the design of lighthouses and harbours (p. 58). Scott Russell's opinion is quoted (p. 106), and accepted, that the most violent action on sea-works is from those waves which form ground-swell or rollers, and are "waves of translation," *i.e.* vast masses of solid water moving horizontally with great velocity; and that the only way of opposing them is by masses too heavy for them to move.

A useful feature of the work is the presentation of 28 cross-sections of quay-, dock-, and harbour-walls, and breakwaters, beginning with the jetty of old Dunkirk (1699); also of 10 cross-sections of lighthouses, beginning with Winstanley's Eddystone (1699).

A chapter (47 pp.) is devoted to materials. A good deal is said about their decay under water. No ordinary material seems free from this. All timber is eventually destroyed by borers (oddly termed *insects* in this work!) of different sorts; even greenheart and creosoted timber, till recently thought borer-proof, have now given way to their special borers. Most stone, and even rock *in situ*, has its own special borer. Iron gives way by rusting, perhaps at a rate of three-quarters of an inch in a century. Bronze alone seems to stand sea-water, but is too expensive to be extensively used.

Ten pages are given to the use of Portland cement concrete, and some remarkable instances of its use are detailed, *e.g.* the concrete cylinder foundations (12 feet diameter, 30 feet length) of the Plantation Quay at Glasgow, and the use of 350-ton blocks (say 5000 cubic feet) laid in 24 feet of water at Dublin (1885).

Attention is drawn to a new and seemingly very promising American cement styled "carbonite," which is said to stand an ultimate pressure of 8000 lbs. per square inch, or *eight times* as much as Portland cement. Trial of this cement in England is much to be wished. Its preparation is apparently a secret, as though four pages are devoted to its use and properties, its main ingredients are only hinted at as being various hydrocarbons.

Two chapters (39 pp.) are given to the difficult subjects of training works for preserving the outfall of harbours and rivers, and preventing silting in estuaries. An interesting instance of the great commercial advantage of even a small increase of depth in a harbour is that of Leith, where an addition of only 2 feet of depth at the Albert Dock gave 296 tides yearly of 23 feet depth against 102 tides of that depth at the Victoria Basin.

Attention is drawn to the disadvantage of harbours being constructed as local instead of as national works. Want of funds has thus repeatedly led to harbours being designed too small for future wants, and being afterwards enlarged at greatly increased cost, the whole works having to be destroyed to make way for the new.

One of the least satisfactory parts of this work is the formulæ, the range of applicability of several of the empirical ones being very doubtful. One (which should have been definite) on strength of lock-gates (p. 191) is misprinted

$$S = \tfrac{1}{2} W \sec \phi + \tfrac{1}{20} \operatorname{cosin} \phi.$$

By reference to the original (*Trans.* Inst.C.E., vol. i. p. 67) it is seen to be

$$S = \tfrac{1}{2} W \sec \phi + \tfrac{1}{20} W \operatorname{cosec} \phi.$$

Moreover, the meaning of $W$ is misquoted as "pressure on the length of the gate, &c.," instead of "pressure on the length $l$, &c." ($l$ being only the half-breadth of lock), and the meaning of the result $S$ is given, in words which are barely intelligible, as "whole transverse strain at angle $\phi$": the context of the original shows that this should be "whole transverse strain applied at middle of gate" (strain being understood to mean pressure). These defects occur in the "Encyclopædia Britannica" (9th ed.) as well as in the separate work (3rd ed.).

On p. 243 a table of values of a "constant" of strength of various timbers is given without explanation of the meaning of the "constant."

Space might have been saved by the exclusion of special subjects, *e.g.* lighthouse apparatus, &c., which could not be treated at adequate length.

A short glossary of uncommon terms would have been decidedly useful, *e.g.* alveus, bollard, kant, pawl, scend, staith.

These blemishes are, however, small compared with the great merit of the work as a whole, which deals with the difficult and important subject of harbours in a thoroughly masterly manner.

ALLAN CUNNINGHAM, (Major, R.E.)

## OUR BOOK SHELF

*A First Course of Physical Laboratory Practice.* By A. M. Worthington, M.A., late Assistant Master at Clifton College. (London: Rivingtons, 1886.)

PROBABLY no one has so successfully carried on practical science teaching in schools as the author whose excellent work at Clifton College has done so much to gain for that institution an enviable reputation. He therefore is specially fitted to write a "First Course of Physical Laboratory Practice" which shall contain just that which the schoolmaster who is endeavouring to supplement mere lectures with the necessary practical work requires.

In the introduction the author explains the system of science teaching at Clifton. He insists on the importance of from the first making boys themselves measure and experimentally confirm geometrical, mechanical, and physical laws, not necessarily with expensive and elaborate apparatus, such as may be best suited for making determinations of the greatest accuracy, but by the most simple and obvious methods, which are likely to lead to results quite accurate enough to show the truth of the law being examined. The pupil is thus from the first taught to learn the value of simple and often extemporised apparatus, instead of acquiring the very general distrust in anything that has not been highly finished by the professional instrument maker.

Here much that is of great value to those intending to introduce practical science teaching into schools will be found, such as descriptions of fittings, original and working cost, and the time that the several courses of instruction should occupy.

The book is divided into nine parts as follows:—1, Mensuration, 23 experiments; 2, Hydrostatics, 15 experiments; 3, Barometer and Boyle's Law, 3 experiments; 4, Mechanics, 39 experiments; 5, Elasticity, 20 experiments; 6, Heat, 42 experiments; 7, Magnetism, 55 experiments; 8, Statical Electricity, 57 experiments; 9, Current Electricity, 16 experiments. The two branches of physics, light and sound, are not included.

The first part is especially valuable as an introduction to laboratory practice of any kind. It is full of examples in which a good way of observation is contrasted with one or more bad ways, so that the pupil soon learns, or ought to learn, method in observation, to choose that way in which error of observation shall least affect the result.

If it is possible to point out any parts as being more excellent than the rest, the chapters on mechanics and elasticity may be mentioned. It is shown how, by means of one or two boxwood scales, a few weights, some pieces of catapult india-rubber (but for sufficient reasons it is not called catapult india-rubber), and some other equally simple and easily obtained articles, a course of experiments of the utmost value can be performed. A pupil must, if he gives his mind to the subject, learn more of the principles of mechanics, of the reasons of things—not the mere "pulley, wedge, and lever" mechanics of the ordinary text-books—than as yet the majority of people have ever acquired.

There is only one sentence which might with advantage be modified as being not strictly correct, though any false impression which it would produce might be removed by the more exact statements five pages later. Having shown that the bending of a lath depends on its length, the author proceeds to show that thickness affects the bending. He says:—"Now take a lath of double the thickness, or, what is the same thing, lay on the first lath a second similar one, and put on the same weight, . . ." This would be a serious blunder to make if the effect of depth were not well shown later. As the fact that the stiffness of a beam is directly proportional to its width is explained by considering it as equivalent to beams side by side, the opportunity is lost, when the effect of depth is considered, of showing that a beam is *not* equivalent to beams lying above one another, and why.

As a text-book for school use, Worthington's "First Course of Physical Laboratory Practice" is highly to be recommended.

*Lectures on Heat, Sound, and Light.* By Richard Wormell, D.Sc., M.A., Head Master of the City of London Middle-Class Schools. (London: Thomas Murby.)

THE distinguishing feature of this book is its gradually progressive character. The subjects are supposed to be taken in the order in which they are given. "*Heat* being far simpler in itself, and so much easier to explain, is placed first, while *Light*, being essentially more intricate than either *Sound* or *Heat*, is placed last." The lectures on *Heat* are adapted to the minds of pupils when first receiving instruction in a scientific subject; as the mind develops the lectures advance in character, so as to make full use of the increased intelligence of the pupil, and ultimately, when light is reached, the perfection of the undulatory theory can be presented with some hope of its being appreciated.

After each of the three parts questions are given, and, what is far more valuable, a few pages of instruction in laboratory practice.

The book is illustrated by many figures, which are often explanatory diagrams rather than pictures. Such diagrams have far more educational value than cuts from photographs of apparatus, but the want of proportion may be carried so far as to give a misleading idea of what a thing is really like—thus, the gridiron pendulum is shown nearly as wide as it is long.

There is a curious slip in Fig. 30, which shows how waves travelling along paths differing by half a wave-length come together again in opposite phases, and so neutralise one another; while, if there is a difference of one or more complete wave-lengths, the phase is the same, and they reinforce one another. The slip—it can hardly be called more than a slip—consists in showing the *same* number of wave-fronts in the longer as in the shorter path.

That the book should contain much that is excellent is only to be expected of an author of such experience, while the necessity for turning to such trivial details for criticism is sufficient to show that fault of a serious kind cannot be found.

*Une Expérience sur l'Ascension de la Sève chez les Plantes.* Par Léo Errera, Professeur à l'Université de Bruxelles. *Comptes rendus* de la Société Royale de Botanique de Belgique, tom. xxv. 2ième partie, 1886.

THIS paper contains an interesting contribution to the question of the course taken by the sap of vascular plants on its way from the roots to the leaves. The view taken by Sachs, that the current passes through the substance of the lignified cell-walls, has, as is well known, been disputed by Böhm, Elfving, and many others, who maintain that it ascends through the cavities of the vessels and tracheides. Various observers have endeavoured to bring the question to an experimental decision by stopping up,